Laboratory Design and Evaluation of an Electric Pulse Fish Crowder for Use at the Tracy Fish Collection Facility

Investigators

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Summary

Federal and state fish screening facilities in the south Sacramento-San Joaquin Delta have been known to provide favorable habitat for predator fish, primarily striped bass *Morone saxatilis* (Gingras 1997 and Bark *et al*. 2009). The flow hydraulics in and around fish screening facilities tend to concentrate predators where water velocities are lower, creating favorable conditions for striped bass (Bark *et al.* 2009*)*. At the Tracy Fish Collection Facility (TFCF), striped bass are frequently found residing upstream, downstream, and within the facility (Bark *et al.* 2009*)*. Striped bass are piscivorous fish that consume smaller fish and can reside within the TFCF year round feeding on seasonal influxes of smaller entrained fish. Thus, striped bass can sustain a viable population within and near the facility as long as they have favorable environmental and feeding conditions (Bark *et al.* 2009*)*. The impact that these resident predators have on salvage rates of threatened and endangered species can be significant (M. Bowen, personal communication).

At the TFCF, the louvers in the primary channel guide fish to one of four 6-inch-wide primary bypasses. The bypasses transition into pipes which carry the fish and flow into a secondary channel. A secondary set of louvers guide fish through another fish bypass and into the holding tank area. Predator fish removal is conducted periodically by lowering the secondary channel water level and manually removing predators. High flows are released through the fish bypasses to force predators out of the bypass pipes where they can be netted and removed. Predator removal is more difficult in the primary

channel due to the larger channel width and water depths. Gill nets and hook-and-line are the current options for predator removal in the primary channel.

This study investigates the use of stationary and moving pulsed electric direct current (DC) fields to deter large predator fish from taking up residency in the primary channel of the TFCF. Electric fish barriers are typically produced by submerging two or more metal electrodes in a fixed location and applying a voltage between them. An electrical current passes between the electrodes, forming an electrical field in the water. Fish in contact with the electrical field can experience a reaction from a slight twitch to full paralysis, depending on the current level and duration.

Electric fish barriers are commercially available, but only limited testing has been conducted to document the effectiveness of electric fields as a behavioral barrier. Reclamation's experience indicates that electric fields may be a potential deterrent in flowing waters (Sechrist and Hiebert, in progress). Past field experience has shown that fish guidance with electric fields is poor in downstream situations, particularly for small fish. Good results were seen in moving larger fish (greater than 6 inches) away from immediate contact with electrodes.

At the TFCF, a stationary field could be used to prevent predators from holding in low velocity zones or in areas where large quantities of small fish congregate. Most fish pass through the final fish bypass at the TFCF (Bates *et al*. 1960), so this may be a region where a stationary field could be applied. An electric field moving from upstream to downstream in the primary channel could force predator fish toward the fish bypasses where they can be contained in the holding tanks or more easily removed in the secondary channel.

In FY 2010, a small-scale laboratory test facility will be designed to develop and measure electrical field strengths specific to the fish species and lengths found at the TFCF. The results of the laboratory study will be used to determine if pulsed electric fields can provide faster movement of large fish through the TFCF and discourage residency of large predators with minimal or no impact on smaller fish.

Problem Statement

The primary objective of this study is to develop and evaluate a small-scale electrode array system using Smith-Root, Inc. (Vancouver, Washington) electric barrier pulse generators and other variable DC voltage generators. Equipment layouts will include both a stationary electric field and a moving electric gradient field. The laboratory study will consist of a physical properties development phase for the electrical field and a fish behavior evaluation phase in a test tank with a mapped voltage field.

Goals and Hypotheses

Goals:

1. What minimum pulsed DC voltage field gradient is needed to force a striped bass of varying size classes to swim away from an electrical field?

2. What minimum pulsed DC voltage field gradient is needed to stun (narcotize) a striped bass of varying size classes?

3. Determine what electric field gradients will not adversely affect small-bodied not-target fish?

Hypotheses:

1. Fishes of varying size classes will not react differently to the same field strength.

2. Pulsed DC voltage field will not have a different effect on predator species as a straight DC voltage field.

Materials and Methods

The first year of the study will be limited to investigations at the Bureau of Reclamation's Technical Service Center laboratory facilities in Denver, Colorado. The study will be conducted in two phases: a physical properties development phase for the electrical field and a fish behavior evaluation phase.

Phase 1 – Several designs of close-coupled electrode arrays will be designed by project researchers with coordination by Smith-Root, Inc. It is anticipated that testing will include both stationary and mobile fields. Voltage mapping near the electric fields will be measured with a field voltage gradient meter. Voltage strengths and uniformity at increasing distances from the electrodes will be recorded for different electrode configurations. The effect of metal objects on the electric fields will be compared to the baseline condition to determine how the primary channel louvers may alter the electrical fields. Since salinity is a conductor of electricity, salinity will be added to the test tank to better replicate water quality conditions at the TFCF.

Phase 2 – The avoidance response of striped bass (predator fish) 6 in and greater to a measured electric field will be evaluated in a large test tank. Behavior will be evaluated by observing reactions to short duration exposure of varying field strengths. Once voltage field limits are identified for both moving and stunning predator fish, prey fish (Chinook salmon *Oncorhynchus tshawytscha*, juvenile steelhead, *O. mykiss*, and adult and juvenile delta smelt, *Hypomesus transpacificus*, depending on availability) will be evaluated under the same field strengths to determine if there are adverse impacts to small-bodied fish.

Data analysis will be formulated based on a stimulus response matrix approach. Three levels of fish behavior (no response, temporary response (twitch), or avoidance) will be contrasted against power density for both predator and prey species. Other responses to electricity that could be observed in fish include orientation to the field (taxis) and stun (narcosis). Fish size (weight, total, and fork length) will be recorded during each test condition.

If laboratory results show that a pulsed DC electric field gradient can be used to alter the behavior of large predator fish, installation of an experimental electrical array at the TFCF will be considered. Details relating to the field evaluation will be included in a future proposal.

Coordination and Collaboration

Fishery biologists and engineers from the Denver Technical Service Center will coordinate with Smith-Root, Inc., to design electrical array alternatives in the laboratory. Smith-Root, Inc., and the laboratory Collateral Duty Safety Officer will be contacted regarding the necessary safety equipment and procedures for working with electrical fields in water. Striped bass, salmon, steelhead, and delta smelt will be acquired and held by Reclamation's Fisheries and Wildlife Resources Group.

Endangered Species Concerns

FY 2010 experiments will be conducted in Reclamation's hydraulics laboratory in a large test tank. Permits for transport and experimental use of endangered species will be obtained.

Dissemination of Results (Deliverables and Outcomes)

Investigators will produce a volume in the peer reviewed Tracy Technical Report Series as the expected deliverable from these laboratory experiments. We also anticipate presenting our finding at a Tracy Technical Advisory Team (TTAT).

Literature Cited

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Smith-Root Inc, Barrier and Guidance Systems, www.smith-root.com.